



US006089701A

**United States Patent** [19]**Hashizume et al.**[11] **Patent Number:** **6,089,701**[45] **Date of Patent:** **Jul. 18, 2000**

[54] **INK JET RECORDING HEAD HAVING  
REDUCED STRESS CONCENTRATION  
NEAR THE BOUNDARIES OF PRESSURE  
GENERATING CHAMBERS**

3-65350 3/1991 Japan ..... 347/68  
5-504740 7/1993 Japan ..... B41J 2/16  
5-286131 11/1993 Japan ..... B41J 2/045

**OTHER PUBLICATIONS**

[75] Inventors: **Tsutomu Hashizume; Tetsushi  
Takahashi; Akira Matsuzawa**, all of  
Nagano, Japan

[73] Assignee: **Seiko Epson Corporation**, Tokyo,  
Japan

[21] Appl. No.: **08/835,748**

[22] Filed: **Apr. 10, 1997**

**[30] Foreign Application Priority Data**

Apr. 10, 1996	[JP]	Japan	8-088469
Dec. 9, 1996	[JP]	Japan	8-344568
Mar. 17, 1997	[JP]	Japan	9-083245

[51] Int. Cl.<sup>7</sup> ..... **B41J 2/045**  
[52] U.S. Cl. .... **347/70**  
[58] Field of Search ..... **347/68, 70, 71,  
347/72**

**[56] References Cited****U.S. PATENT DOCUMENTS**

4,296,421	10/1981	Hara et al.	347/68 X
4,516,140	5/1985	Durkee et al.	347/71
4,588,998	5/1986	Yamamoto et al.	347/68
4,897,673	1/1990	Okbayashi et al.	347/68
5,459,501	10/1995	Lee et al.	347/68
5,872,583	2/1999	Yamamoto et al.	347/71 X

**FOREIGN PATENT DOCUMENTS**

0572230	12/1993	European Pat. Off.
0698490	2/1996	European Pat. Off.
4443254	12/1995	Germany

Patent Abstracts of Japan, vol. 9, No. 14, Jan. 22, 1985, JP  
59 164150 A (Nippon Denki K.K.)  
Patent Abstracts of Japan, vol. 15, No. 57, Feb. 12, 1991, JP  
02 289352 A (Seiko Epson Corp.)  
Patent Abstracts of Japan, vol. 7, No. 9, Jan. 14 1983, JP 57  
167272 A (Hitachi Seisakusho K.K.)  
Patent Abstracts of Japan, vol. 4, No. 179, Dec. 11, 1990, JP  
55 126463 A (Ricoh K.K.)  
Patent Abstracts of Japan, vol. 8, No. 197, Sep. 11, 1984, JP  
59 087167 A (Ricoh K.K.)

*Primary Examiner*—John Barlow

*Assistant Examiner*—C Dickens

*Attorney, Agent, or Firm*—Sughrue, Mion, Zinn, Macpeak  
& Seas, PLLC

**[57] ABSTRACT**

An ink-jet recording head comprising: an elastic sheet providing pressure generating chambers; nozzle orifices, each communicating with the pressure generating chamber; piezoelectric vibrators formed on the elastic sheet, each of the piezoelectric vibrators having, a lower electrode formed on the elastic sheet, a piezoelectric layer formed on the lower electrode, and an upper electrode formed on the piezoelectric layer such that the upper electrode faces the respective pressure generating chamber, wherein the upper electrodes of the piezoelectric vibrators are positioned independently of each other; an electrical insulator layer having windows, wherein the electrical insulator layer covers the upper electrodes; and a conductor pattern connecting with the upper electrodes via the windows of the electrical insulator layer.

**12 Claims, 7 Drawing Sheets**